PERSISTENCE IN COMBAT

"Medicine for Non-Medics"

Toward an Accelerated Self-Healing Warfighter

Dr. Kurt A. Henry, CDR, MC, USN

DARPA DSO

PIC

PERSISTENCE IN COMBAT

"Focus medical research toward battlefield benefits from revolutionary advances in medicine"

Dr. Anthony J. Tether
Director of DARPA

DARPA

Executive Summary

PERSISTENCE IN COMBAT

PROGRAM VISION

1. **Accelerate** warfighter physical **healing** capabilities to achieve battlefield Persistence In Combat.
2. Create a **paradigm shift** from medic-centric to warfighter-centric medical care to ensure medical readiness.
3. **Integrate technology** into Personnel Recovery, Future Naval Capabilities, and Objective Force Warrior Programs.

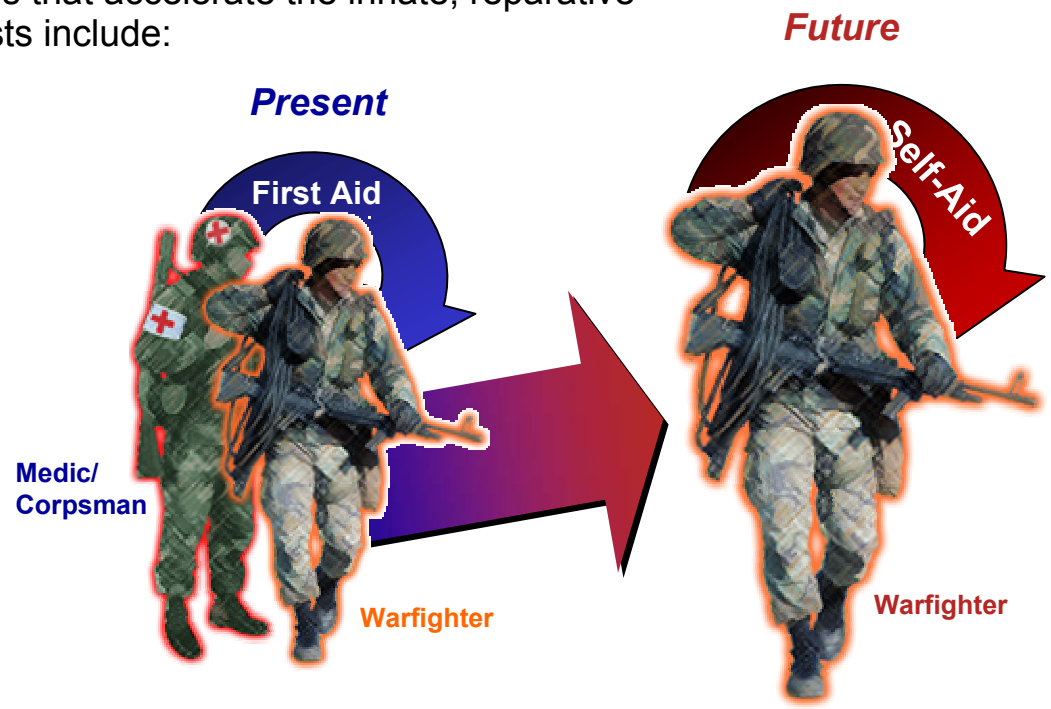
TECHNICAL APPROACH

Develop adaptive broad-spectrum technologies that accelerate the innate, reparative processes of the human body. Scientific thrusts include:

- Incapacitating minor tissue injury.
- Acute hemorrhage.
- Acute intractable pain.

KEY ACCOMPLISHMENTS

- Developed prototype handheld photobiomodulation device.
- Demonstrated that neurotransmitters affect endothelial cell cytokine expression.
- Identified antibody inhibitor of pain-producing peptide.



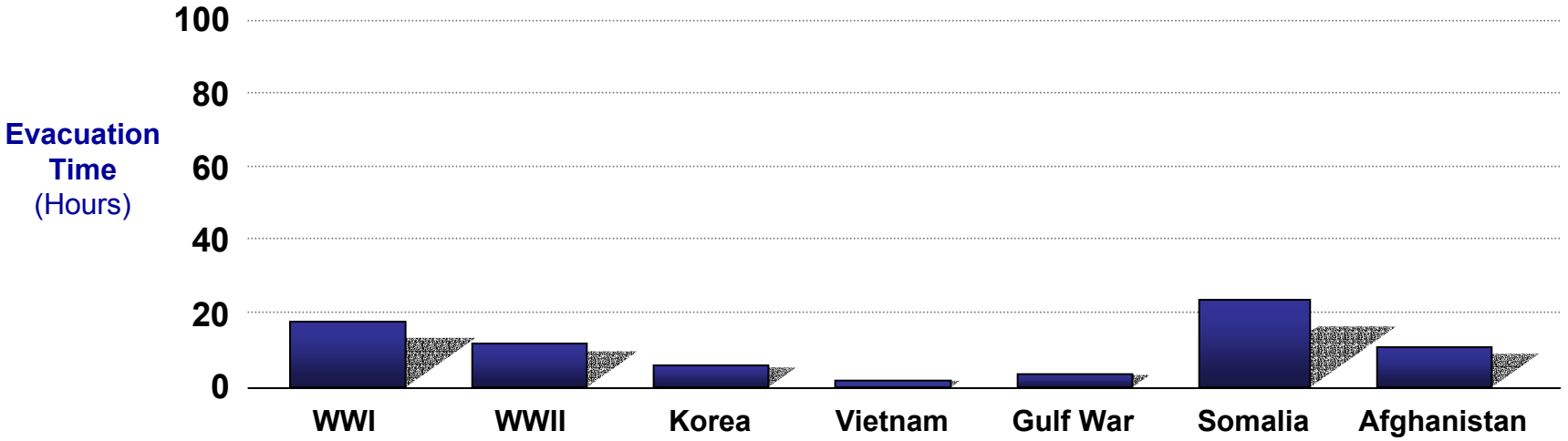
DARPA DSO

The Problem

PERSISTENCE IN COMBAT

- **Future warfare will be urban:**
  - Fewer medics/corpsmen.
  - Evacuation difficult/medical care remote.
  - Increased need for high mobility/limited carrying load.

Evacuation Times by Conflict



Program-Specific Objectives

PERSISTENCE IN COMBAT

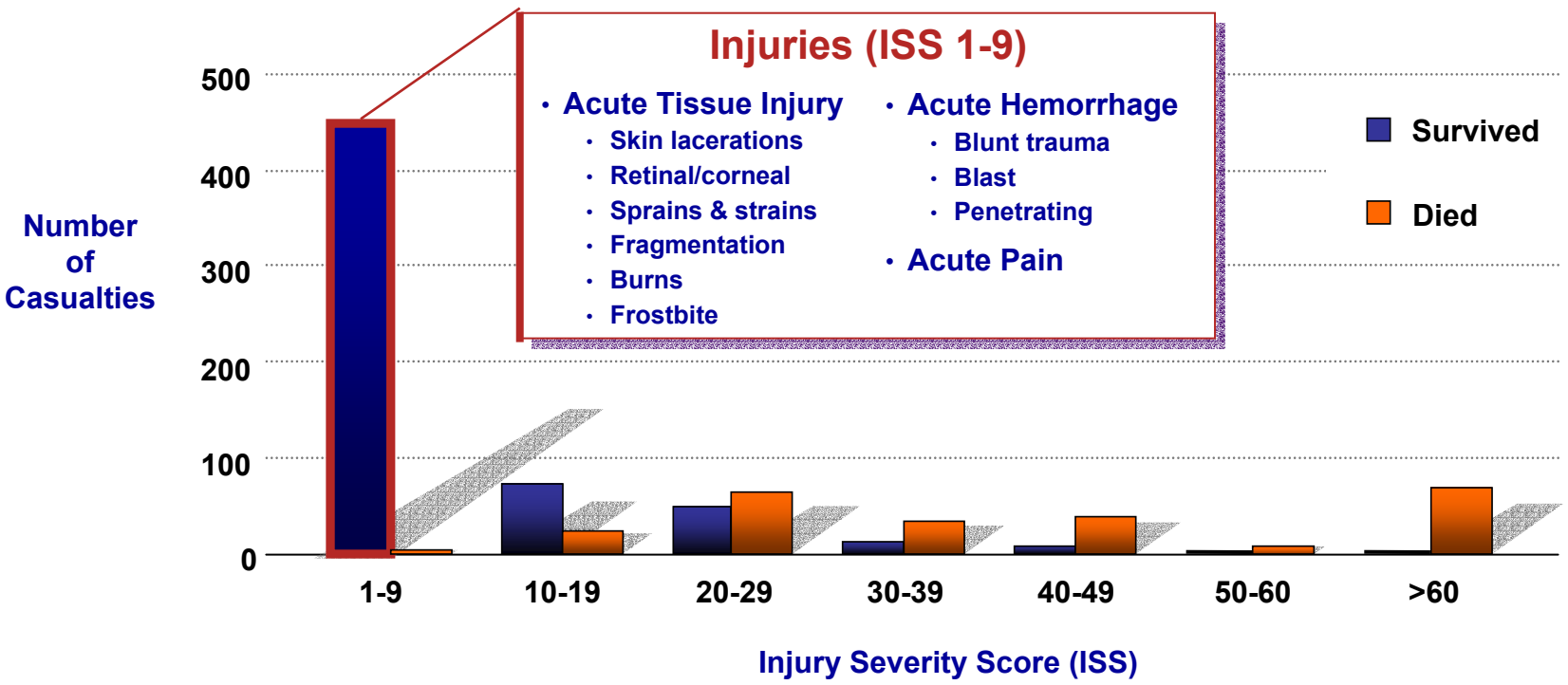
- A tenfold increase in the number of warfighters using self-aid techniques in the battlefield.
- A fourfold increase in the rate of tissue repair.
- A major reduction in the number of battlefield evacuations due to minor injuries.
- A physically functional warfighter 96 hours post-injury, resulting in a decrease in convalescent leave.
- Control of pain and treatment initiation within 5 minutes of injury for more rapid stabilization.
- Demonstrated reduction of medical logistical load by 60 percent.

Most Common Injuries

PERSISTENCE IN COMBAT

- **Majority of battlefield casualties are mild to moderate.***

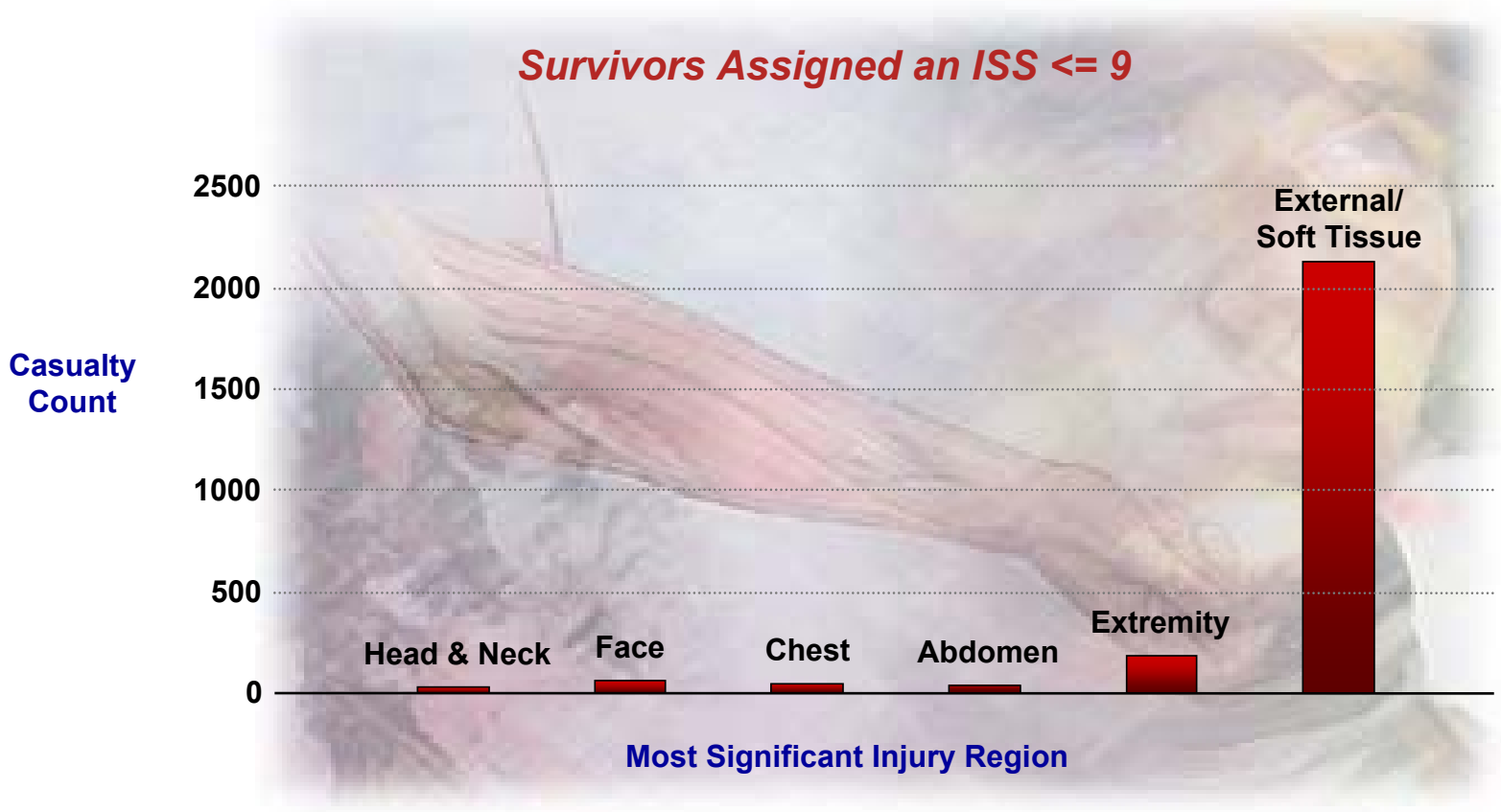
Vietnam Casualties



• Wound Data and Munitions Effectiveness Team (WDMET) Study, Data Collection June 1967- June1969, Statistical Analyses Completed 2002, Rick Pruett, M.D., Uniformed Services University of the Health Sciences

ISS <= 9 Injury Breakout

PERSISTENCE IN COMBAT



- Wound Data and Munitions Effectiveness Team (WDMET) Study, Data Collection June 1967- June1969, Statistical Analyses Completed 2002, Rick Pruett, M.D., Uniformed Services University of the Health Sciences

The Solution

PERSISTENCE IN COMBAT

- **Paradigm shift from a medic-centric to a warfighter-centric model to provide self-aid medical care.**
  - Enable survival without evacuation.
  - Reduce medical logistics burden.
  - Maintain battlefield OPTEMPO.
- **Acceleration of the warfighter's physical healing capabilities to allow continued operation in all terrains of conflict and reduce reliance on a fixed infrastructure of medical care.**

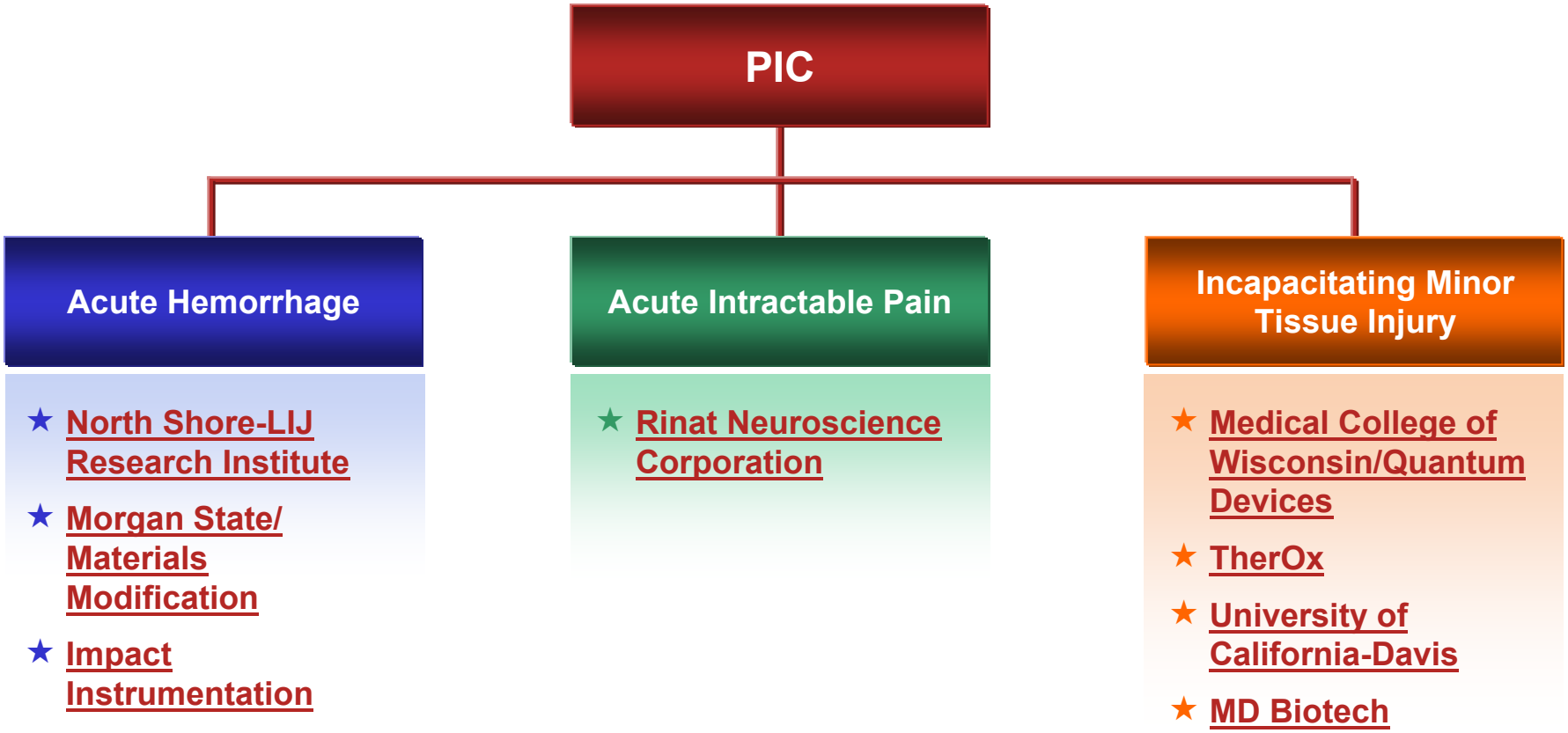
Specific Program Goals

PERSISTENCE IN COMBAT

	Medic-Centric	Warfighter-Centric
Evacuation	>50%	5%
Treatment Initiated	20 min	< 5 min
Pain Relief	20 min	< 5 min
Casualty Stable	30-45 min	5 min
Convalescent-Leave	21 days	96 hours

Program Thrusts/Performers

PERSISTENCE IN COMBAT



Transition Planning

PIC
PERSISTENCE IN COMBAT

- **PIC transition plan began at conceptual phase.**
- **Immediate involvement of the military services/end users:**
  - Addresses immediate capability deficiencies/needs.
  - Provides real-world operational testing opportunities.
  - Identifies promising transition partners for relevant technologies.
  - Facilitates the migration of novel self-aid technologies to existing military systems.

Persistence In…

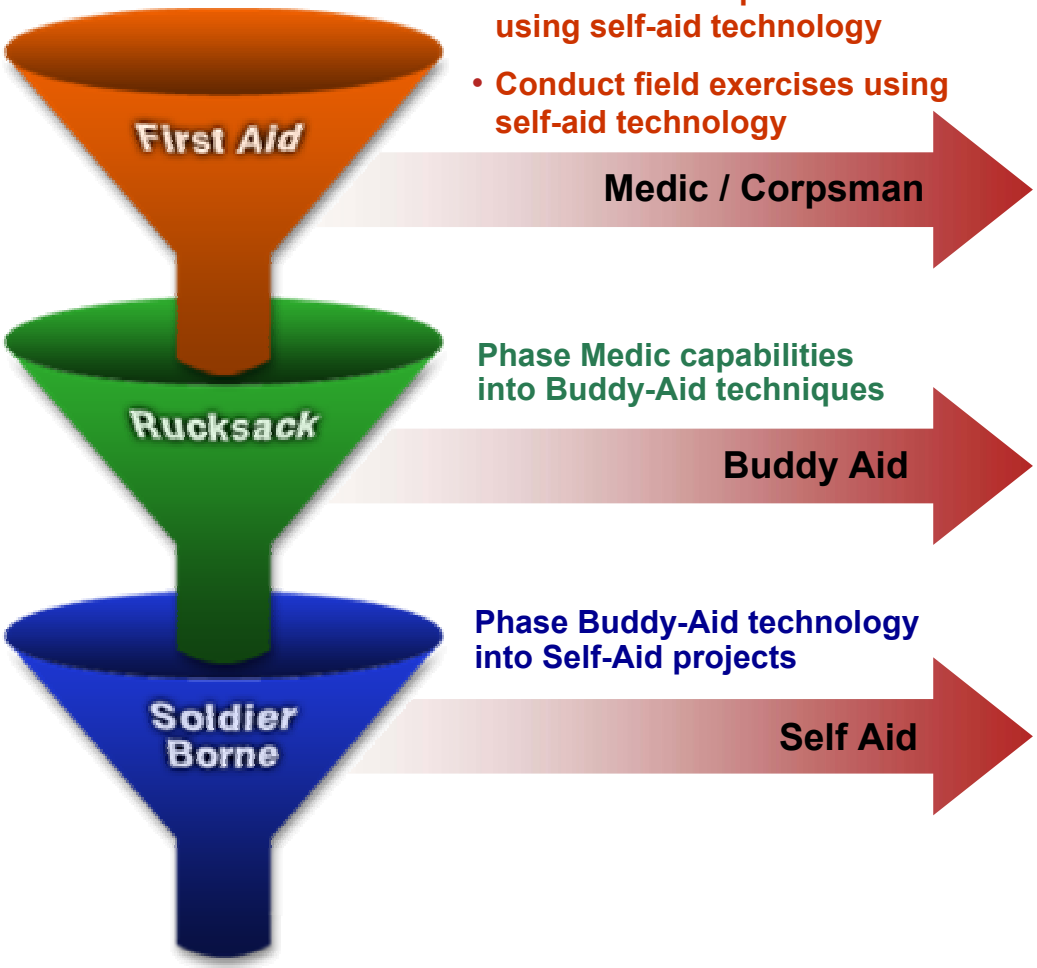
PERSISTENCE IN COMBAT

DARPA DSO

PIC Military Transition Plan

PERSISTENCE IN COMBAT

PIC Technology



- Conduct tabletop exercise using self-aid technology
- Conduct field exercises using self-aid technology

Medic / Corpsman

Phase Medic capabilities into Buddy-Aid techniques

Buddy Aid

Phase Buddy-Aid technology into Self-Aid projects

Self Aid

Integrate Self-Aid technology to existing warfighter platforms

DARPA DSO

Meeting the Medical Needs for Revolution of Military Affairs

PIC
PERSISTENCE IN COMBAT

Echelon 4	Echelon 3	Echelon 2	Buddy-Aid	Self-Aid

- Fixed medical assets
- Excessive medical logistics
- Medic-centric

- Self-reliant medical care
- No triage

- Land Warrior
- Objective Force Warrior
- Scorpion

1950-Present **1998** **1999** **2008**

- Reliance on echelons of care
- Casualty-based triage system
- Doctor-centric

Buddy-Aid

- Portable medical assets
- Reduced medical logistics

DARPA DSO

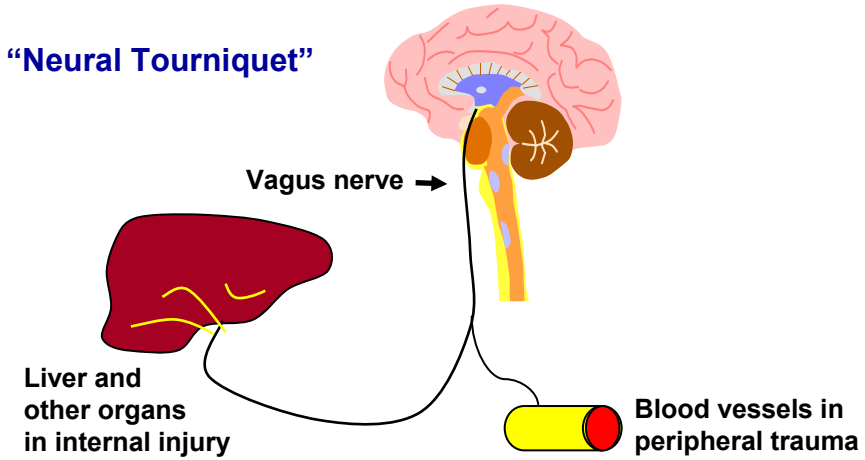
The Vagus Nerve and Hemorrhage: Exploring the Neural Tourniquet

North Shore–Long Island Jewish Research Institute

PERSISTENCE IN COMBAT

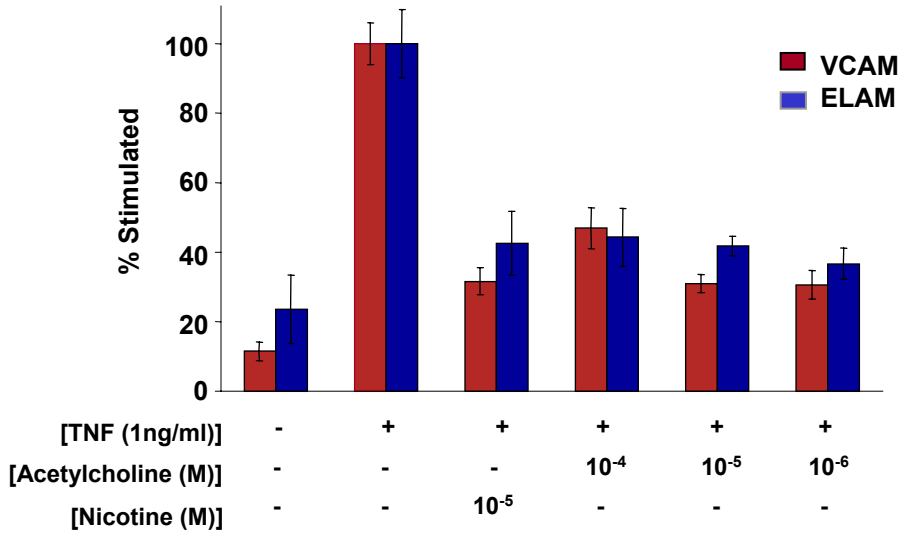
MISSION

- The human immune system has evolved comprehensive mechanisms to fight invading pathogens, and trigger coagulation and wound healing.
- Parasympathetic nervous system activity influences molecular mechanisms to mediate inflammation, shock, and death.
- Activation of neural signaling may trigger peripheral nervous system signals to prevent excessive hemorrhage and shock.



TECHNICAL CHALLENGES

- Demonstrate an effect of neurotransmitters on molecular coagulation factors.
- Identify methods to harness the nervous system to control bleeding and blood flow.



DARPA DSO

North Shore - Long Island Jewish Health System
North Shore-LIJ Research Institute

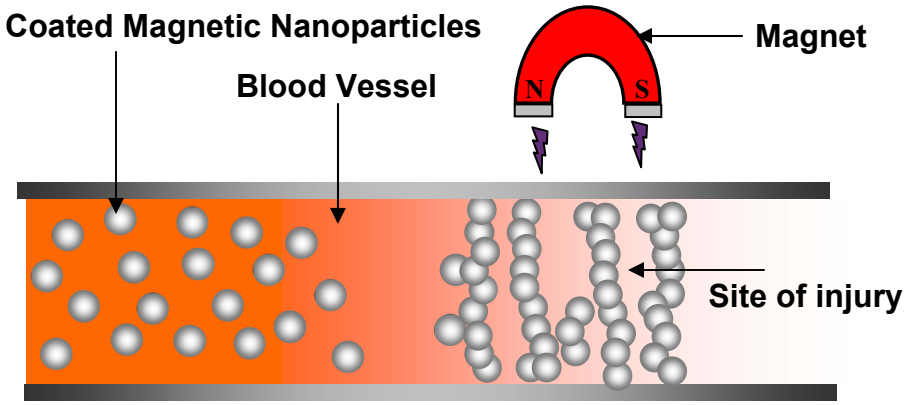
Innate Magnetic Tourniquet

Materials Modification, Inc.

PERSISTENCE IN COMBAT

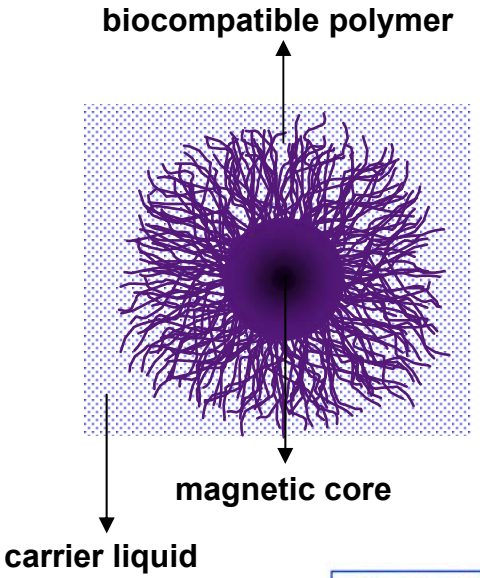
MISSION

- Develop biocompatible and non-toxic magnetic nanoparticle-based fluids.
- Enable nanoparticle-based fuild to reversibly gel upon interaction with a magnetic field to cause site-specific hemostasis.
- Control internal non-compressible hemorrhage.



TECHNICAL CHALLENGES

- Synthesis of non-toxic and bicompatible magnetic nanoparticles with control in size, shape and composition.
- Formulation of magnetic fluids at low particle concentrations.
- Stability of particles in a continous media such as blood plasma.
- Controlled flow of nanoparticles inside a blood vessel and non-blockade of other vessels.



DARPA DSO

Materials Modification Inc.
The Home of Futuristic Materials

MORGAN

Automatic Emergency Ventilator

Impact Instrumentation

PERSISTENCE IN COMBAT

MISSION

- Develop an Automatic Emergency Ventilator (AEV) that monitors an injured warfighter's respiratory condition and in response, evokes a therapeutic action.
- Develop an AEV that can be used in austere environments and requires only the initiation of power and attachment to the patient via a facemask or airway to function.

Provide automatic and self-responding ventilatory care to the warfighter to enhance survivability.

TECHNICAL CHALLENGES

- Automatically control respiratory parameters to maintain ventilation and oxygenation and improve survivability.
- Develop a user interface that guides the untrained warfighter to provide enhanced care using standardized treatment procedures and context sensitive help.
- Develop an automated electronic medical record system that stores, summarizes, and transmits clinical data as the patient moves through the echelons of care.

DARPA DSO

IMPACT™

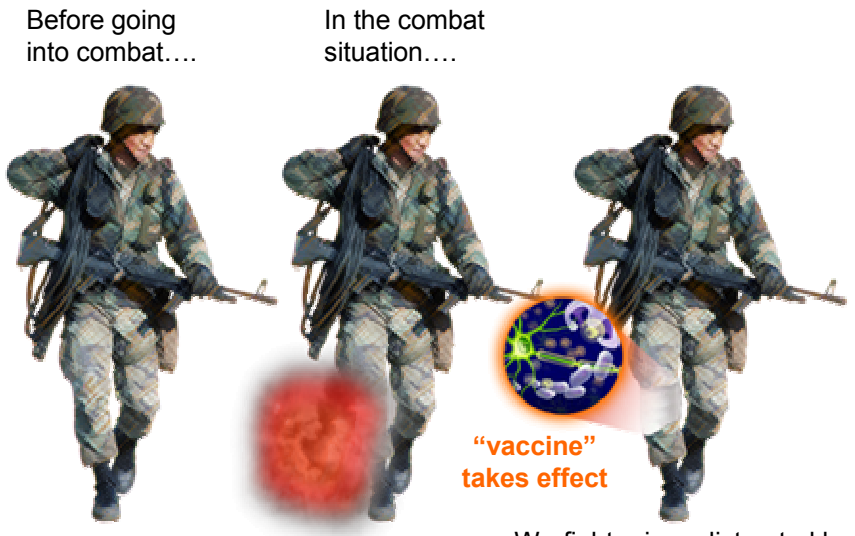
Development of a Pain "Vaccine"

Rinat Neuroscience Corporation

PERSISTENCE IN COMBAT

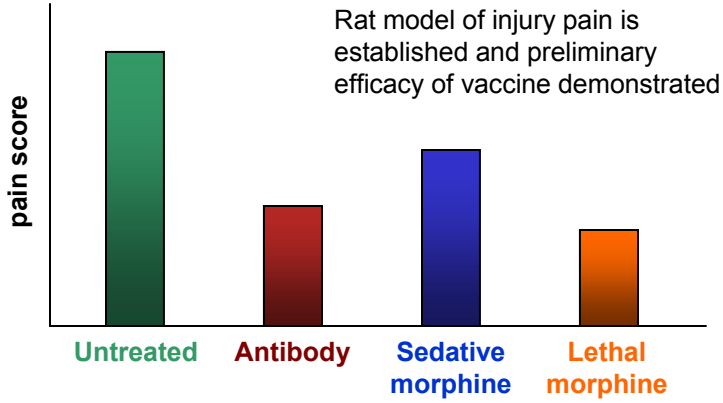
MISSION

- Pre-deployment pain therapeutic.
- Activated post-traumatic injury.
- Maintains alertness, judgment, and strength.
- Preserves tactile sensation and protective pain while eliminating traumatic pain.



TECHNICAL CHALLENGES

- Demonstrate effectiveness in relieving pain in an animal model of injury pain.
- Humanize the antibody.
- Demonstrate safety and lack of side effects that could affect the vigilance and performance of the warfighter.
- Retain sufficient protective pain sensation to avoid negligent injury.



PhotoBiomodulation for Treatment for Acute Traumatic Neurological Injury

Medical College of Wisconsin / Quantum Devices

PERSISTENCE IN COMBAT

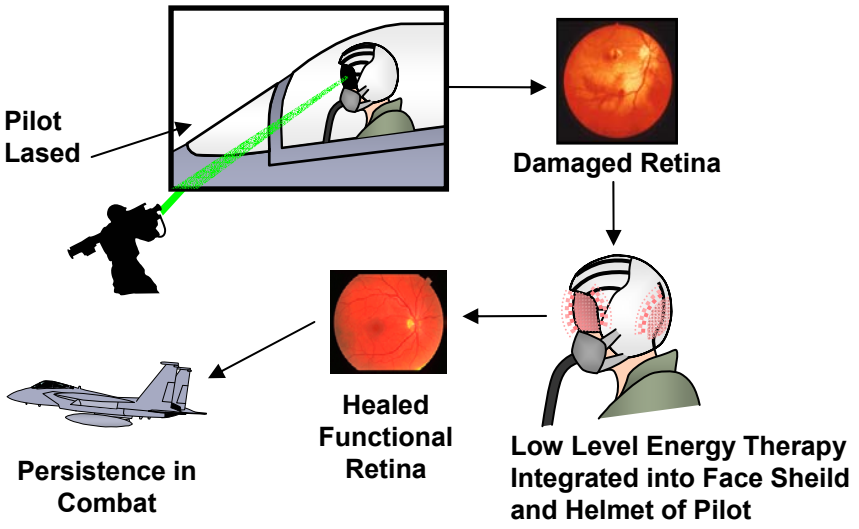
MISSION

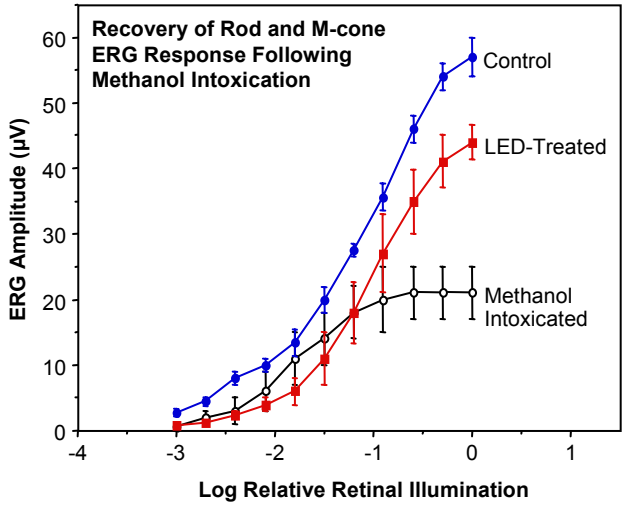
To provide the warfighter with low-level energy light arrays that will—

- Dramatically accelerate healing and retinal wound repair on battlefield.
- Stimulate visual cortex neuronal regrowth to restore vision after a laser weapon exposure.
- Identify and enhance molecular mechanisms specific for healing process.
- Enhance biophotostimulation of retinal cells.

TECHNICAL CHALLENGES

- Incorporate technology for field use:
  - Power Density
  - Size
- Optimize treatment regimen.
- Assess functional recovery from acute retinal trauma other peripheral neurological damage.
- Protect against mitochondrial failure by stimulating cellular energy production





Recovery of Visual Function

DARPA DSO

Quantum Devices | Medical College of Wisconsin

A Supersaturated Oxygen Topical Emulsion for Wound Healing

TherOx

PERSISTENCE IN COMBAT

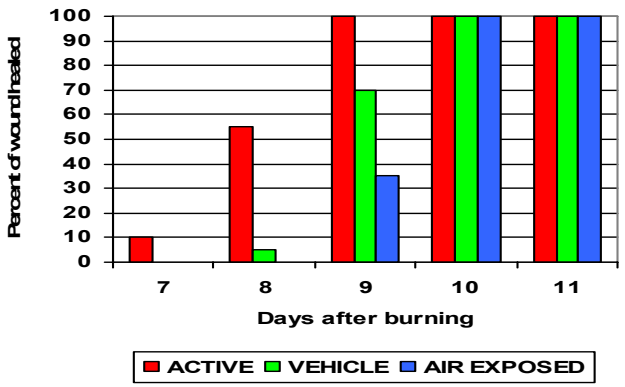
MISSION

- Create a stable topical emulsion containing high levels of dissolved oxygen for enhanced wound healing.
- Provide the warfighter with a small and easily portable oxygenated system (hyperbaric oxygenation chamber in a tube) for effective treatment of minor to moderate injuries in the battlefield.

Oxygenated Emulsion in a tube/canister

TECHNICAL CHALLENGES

- Develop a biocompatible and stable perfluorocarbon-based emulsion.
- Develop a system that allows the emulsion to be charged and maintained with oxygen under hyperbaric conditions.
- Elucidate the effect of topical oxygenated emulsion on wound healing.



Enhanced Wound Healing with Oxygenated Emulsion (active) in a 2nd degree burn porcine model

DARPA DSO

TherOx

Electrical Stimulation of Wound Healing

University of California–Davis

PERSISTENCE IN COMBAT

MISSION

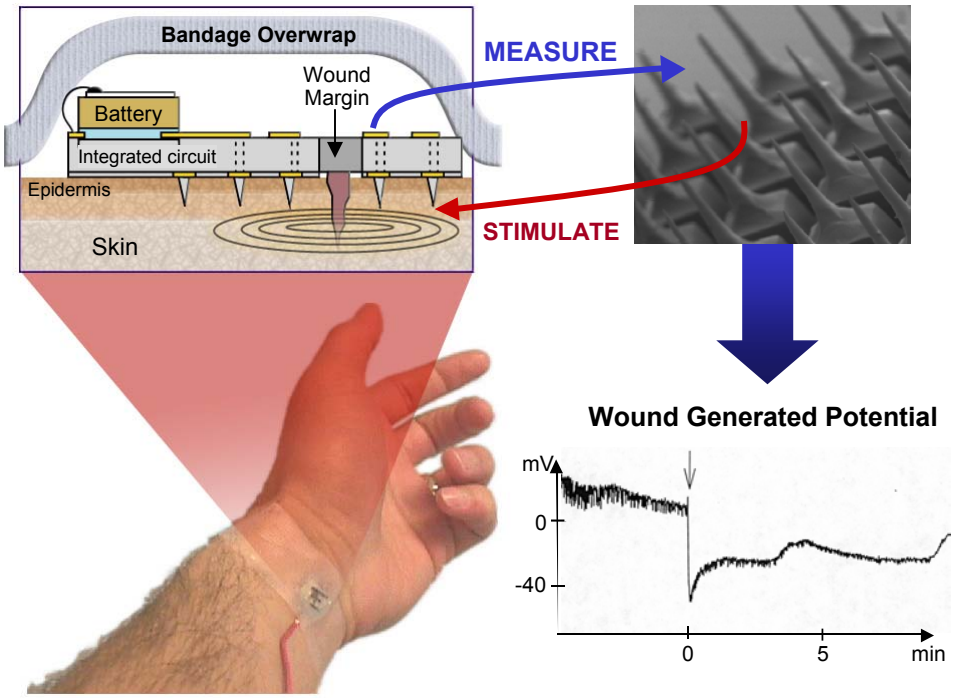
Devise an electronic "smart" bandage device that can—

- Sense the electric field generated by a wound.
- Deliver exogenous electrical stimulation as needed to optimize skin wound repair.

TECHNICAL CHALLENGES

- Construct needle microelectode array with reliable repeatable electrical characteristics.
- Establish metrics for electrical stimulation of wound healing.

The "Smart" Bandage



Ocular Scanning Instrumentation

MD Biotech

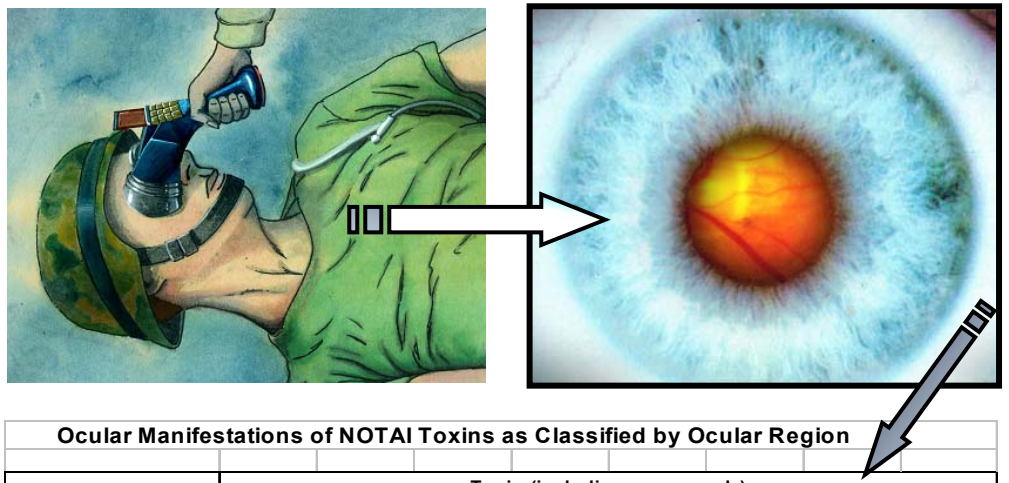
PERSISTENCE IN COMBAT

MISSION

- Provide the warfighter with a portable triage diagnostic for ocular biomarkers induced by exposure to chemical/ biological agents, trauma, and other environmental toxins.
- Close the gap in combat casualty care by providing the warfighter with a self-diagnostic technology.

TECHNICAL CHALLENGES

- Identify ocular biomarkers of exposure to various classes of chemical/biological threat agents.
- Develop a matrix of ocular and other physiological biomarkers leading to non-invasive diagnosis of exposure to threat agents.
- Develop the ocular imaging technology to support the experimental phase of this project.



Ocular Manifestations of NOTAI Toxins as Classified by Ocular Region

Affected Region of the Eye	Toxin (including compounds)							
	CO	CN	As	Hg	Pb	U	antiChE's	Botox
Eyelids		✓	✓	✓			✓	✓
Tear glands		✓	✓			✓	✓	
Extraocular muscles		✓	✓	✓	✓		✓	✓
Cornea	✓	✓	✓	✓			✓	
Conjunctiva	✓	✓	✓	✓		✓		
Sclera		✓	✓	✓				
Iris		✓					✓	
Pupil	✓	✓			✓		✓	✓
Ciliary body							✓	
Lens		✓		✓		✓		
Vitreous humor			✓					
Retina	✓	✓	✓		✓		✓	
Optic nerve		✓	✓	✓	✓	✓		
Optic disk	✓		✓		✓			
Eye blood vessels		✓	✓		✓			
Intraocular muscles			✓	✓	✓		✓	
Vision	✓	✓	✓	✓	✓		✓	
Visual Fields	✓		✓	✓	✓		✓	
ERG, EEG, EOG, VER	✓	✓		✓	✓		✓	
Local effects		✓	✓	✓	✓	✓	✓	✓

DARPA DSO

MD BIOTECH

WestVirginiaUniversity.